

## Commercialization Analysis & Roadmap

**Title: Superhydrophilic Nanostructures**

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### Technology

TiO<sub>2</sub> based nanoparticles are used to form a superhydrophilic surface that prevents water droplets from forming on glass. The geometry of these nanoparticles enables the anti-fogging effect without the need of any external stimuli, such as heat, chemical inputs, or sunlight. The resulting coating is stable under successive wetting-de-wetting cycles, remains transparent, and exhibits self-cleaning properties. The material is synthesized using sol-gel process and the coating is applied using a drop-and-dry method. The optical properties of the coating are superior to those of other formulations in its class, demonstrating higher transmittance (> 90%) and reduced reflectance (6-8% over wavelengths of 300-2,500 nm)<sup>1</sup>. This Berkeley Lab invention is a 2011 R&D 100 Award Winner.

### Applications

The anti-fogging and self-cleaning aspects of this technology are traditionally applicable primarily in weather-exposed windows, building exteriors and automotive windows as the need for UV irradiation in conventional technologies limits the de-fogging effects to be functional only under the presence of sunlight. In this aspect, LBNL's technology has an obvious advantage and many promising niche applications exist that leverage its non-UV activation including dental mirrors, food packaging, shower doors, mirrors and enclosures, eyewear (goggles and glasses), camera lenses, endoscopes, laparoscopes, and other optical devices. The superior transparency properties of this LBL technology in conjunction to its self cleaning ability can also be applied to solar panels which can lose as much as 40% of their efficiency within six months due to accumulation of dust and dirt on their surfaces<sup>2</sup>.

### Market

NanoMarkets sees the automotive sector as the largest segment of the self-cleaning windows market by 2018<sup>3</sup>. It is projected that by this time, revenues from automotive markets will in fact become comparable to those from architectural markets<sup>3</sup>. In 2006, MIT calculated that as a replacement to electric defrosting systems in automobiles, the potential size of the anti-fogging glass market is an estimated US\$6.08 billion<sup>4</sup>. Nonetheless the present size of the advanced flat glass market segment is valued at \$370 million, distributed primarily over four major competitors – Asahi Glass Co. of Japan, Pilkington of the United Kingdom, Guardian Industries of the United States and Saint-Gobain of France<sup>4,5</sup>. These together account for 61% of global flat glass production<sup>4</sup>.

### Economics

The researchers anticipate a manufacturing cost of \$0.10-\$0.20/m<sup>2</sup> for the nanostructured antifogging self-cleaning coatings. According to Pilkington, in the case of Activ<sup>TM</sup> (a competing self-cleaning technology), the payback period varies from 3-11 years for apartment and office buildings<sup>6</sup>. It was reported that the whole life cost of a building including the capital costs and the maintenance and running costs (including window cleaning) over the lifetime of the buildings is lower when Pilkington's Activ<sup>TM</sup> glass was used<sup>6</sup>. Nevertheless, self-cleaning windows are still 20% more expensive than uncoated windows.

## Competitive Landscape

Several TiO<sub>2</sub> based superhydrophilic technologies (e.g. TOTO, MCH Nano Solutions) exist on the market but they all require the use of UV irradiation and many of them are toxic, preventing their use on niche applications such as bathroom installations, dental and surgical devices. In addition, current commercial self-cleaning glass such as Pilkington's Activ™ and PPG's SunClean® have been on the market for almost 10 years. Both coatings are hydrophilic and photocatalytic with dirt-breaking properties that are claimed to last up to 10 years. The coatings are applied during the manufacturing process as an integral part of the glass, significantly reducing the manufacturing cost. Hence the current competitive environment represents a barrier to new entrants.

## Driving Forces

As an exterior architectural application, LBNL technology's additional functionality in water sheeting and non-UV activation may not add value to glass manufacturers unless it is cost competitive or offers solar control. In automotive applications, windshields are not entirely flat, and the coating process has not yet been tested on curved surfaces. However, the self-cleaning/antifogging constraints on interior bathroom glass applications (mirrors and stalls) are much less strict, and the need for technological improvements is less likely to hinder further product development.

## Advantages

LBNL's technology has technical advantages over existing self-cleaning and anti-fogging glass as it can be used in both indoor and outdoor applications as it circumvents the need of external stimuli and it doesn't require repeated application. In addition, the solution based process could significantly lower the fabrication cost, however, incorporation of the coating into existing glass manufacturing process will be key to its success. In business settings, reduced production costs have a definite value, while for commercial and residential owners it is the timesaving that is appreciated.

## Intellectual Property

Published patent application US2010/033927 available at [www.wipo.int](http://www.wipo.int). The technology is available for licensing or collaborative research.

## Readiness

The technology has proven effective for small areas and although large area applications are feasible, they have not yet been demonstrated.

## Licensing Strategy

Transportation costs are significant in the flat glass industry and are estimated to take up to 10% of total cost<sup>4</sup>. In addition, typical land transportation distance is limited to 200km with 600km as being the economic limit<sup>4</sup>. Hence the technology could go to an existing glass manufacturing corporation with the capabilities to perform in-house coating operations or the equipment vendors who can utilize the technology to provide glass manufactures with the necessary coating apparatus. Licensing to the glass manufacturers would also leverage the large sales volume of these companies that can translate into a healthy cash flow in the form of royalties as well as service a global market. However, the technology also provides a suitable platform for a startup. A competitive advantage can be maintained through continual improvement of the technology and expansion of IP. This business

model was successfully executed by competitor - TOTO Ltd. TOTO Frontier Research was instituted shortly after the release of their Hydrotec™ coating, and was responsible for continuing R&D and commercialization to manufacturers such as PPG Industries Inc., Asahi Glass Co. Ltd. and Nippon Sheet Glass Co. Ltd<sup>4</sup>.

One of the largest flat-glass manufacturers in the United States (Guardian Industries) sells ShowerGuard glass. The glass permanently preserves clarity from stains caused by hard water, cleaning products, heat and humidity. This is a viable technology partner to co-innovate LBNL's self-cleaning and antifogging technology with, and it recommended that research collaborations or licensing to Guardian Industries be pursued.

**Next Steps**

- Produce a lab prototype for large area applications that can validate its feasibility for scale-up production.
- Demonstrate feasibility for curved glass surfaces such as window shields

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## References

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